Power/Forward Carolinas

A 10-Year Plan to Modernize South Carolina's Energy Grid

About this overview

The purpose of this report is to provide an overview of the Power/Forward Carolinas grid improvement plan and highlight the benefits and value to the Duke Energy customers of South Carolina.

We will periodically revise this document to reflect any material updates in the work plan or budgets through the duration of this long-term initiative.

Contents include:

The Need is Clear …………..2
Seven Strategic Programs….6
Four Corners of Value……..13
Conclusion…………………..17
Appendices………………….18

January 2018

1.0 THE NEED IS CLEAR

Technology is driving profound change across South Carolina, and changing the way customers use electricity and interact with their electric provider. Customers want a new experience, built upon information about how they personally use energy and tools to harness that energy and power their lives. Their desire is simple – perfect power, every day, every hour..

From routine, day-to-day activities -- like charging a cell phone – to powering high-tech manufacturing, the electric power grid has become the backbone of our state's digital economy and the electrons that flow through the grid are its virtual lifeblood.

To meet these high expectations, we cannot simply maintain the grid of Edison's imagination. The grid and its components are aging, outage events and duration are increasing, and technology is pushing the machine beyond its limits.

The time is now to reimagine the way we deliver electricity to customers. The time is now to build a more intelligent, resilient power grid, built to provide customers with a better energy experience and built to power South Carolina forward in the years ahead.

Customer expectations have changed

Customers – more than ever – expect more options, greater reliability and value. This change in expectations has been greatly influenced by the ongoing evolution and disruption of retail markets, both online and in physical outlets, resulting from increased e-commerce, or the "Amazon Effect." Self-selecting billing and payment dates, scheduling appointments, accessing real-time data, perfect power and immediate service repairs after outages are all examples of basic services consumers expect but require technology to deliver.

A 2017 J.D. Power and Associates satisfaction study of electric utility residential customers confirms this shift in expectations, finding, among other things that:

- Customers are increasingly going directly to their utility's website for information, with more than one-third of customers accessing website content by mobile phones or tablets.
- Customers who experience an extended outage are less satisfied when the outage is caused by equipment failure (Duke Energy's fault) vs. a hurricane or auto accident.

- Customer satisfaction increases during outages with each additional piece of information that is provided (e.g. outage start time, outage cause, number of customers affected)
- Customers are more satisfied with the price they pay, and even increases in that price, when that money is used for infrastructure investment, reliability, cleaner generation and enhanced service.

To deliver on customer expectations, we must do more than maintain the power grid; we must make the appropriate investments to transform it, leveraging technology to modernize its operation, making it more reliable, smart and secure.

People rely on electricity more than ever to power their lives and businesses. Power is no longer a convenience nor is it a luxury.

Increasingly, all electric power customers, whether residential, industrial or commercial, rely upon electricity every minute of every day. Like the roads and bridges that connect communities across the state, electricity is part of the critical infrastructure of the South Carolina.

At Duke Energy, we currently invest $1 billion annually in preventative maintenance for our reliable grid. Year-after-year, we have replaced mechanical components with mechanical components. But the capability of the grid has remained essentially unchanged, even as customer expecations and the technology have changed exponentially. The needs of 21st-century customers cannot be effectively met without implementing a 21st-century grid to match.

Proven industry data including System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) metrics are reflecting our power grid's experience with increased weather events and greater demands. Recent benchmarking against utility peers reveals that Duke Energy Progress and Duke Energy Carolinas are in or nearing fourth quartile performance for reliability.

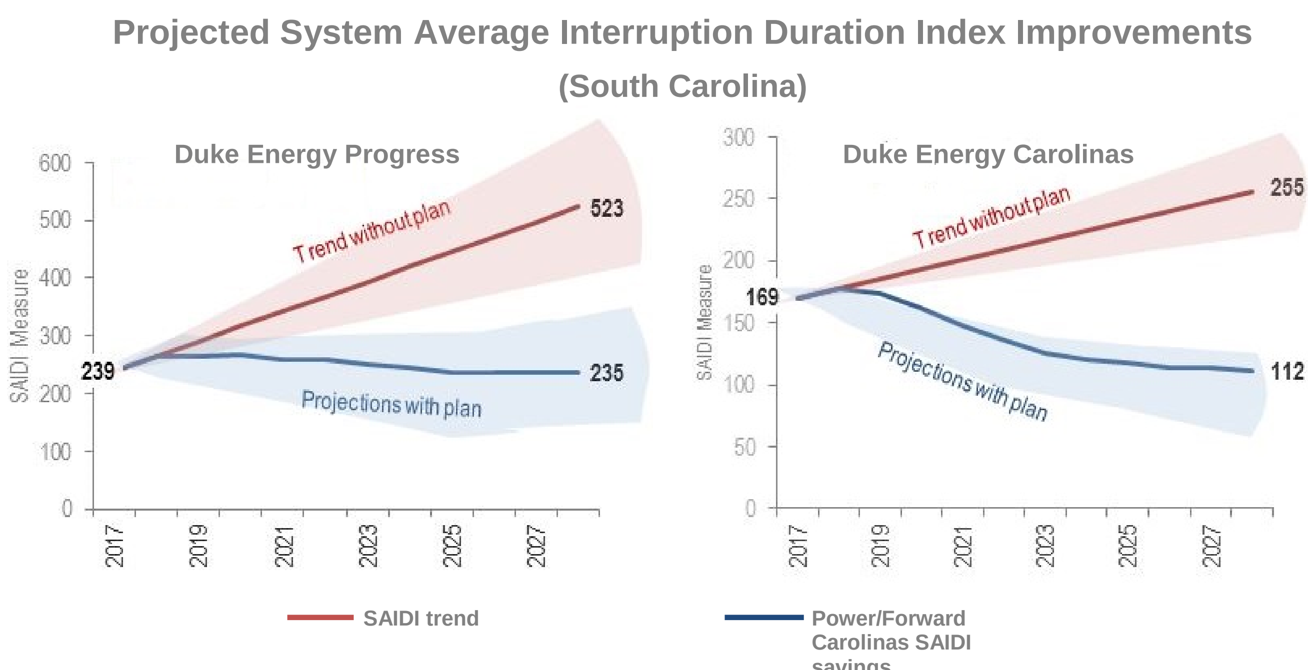


Figure 1 – 10 years of projected South Carolina SAIDI values starting with the 2017 year-end projection and ending at the 2028 year-end projection. The information charted denotes 10 years of SAIDI projections both with and without Power/Forward Carolinas for DEC and DEP (SC only).

Power/Forward Carolinas will reduce the number and duration of routine outage events for customers. To determine the reliability improvements expected from Power/Forward Carolinas programs, our engineers applied decades of historical data from tracking performance of power reliability programs and projected the impacts of the individual program measures found in Power/Forward Carolinas. Those improvements were factored into the SAIDI and SAIFI forward-looking trend projections to produce the performance with the Power/Forward Carolinas impacts (blue lines in Figure 1.) To acknowledge the increasing uncertainty of these projections further out in time, we have overlaid cones of uncertainty for each reliability measure forecast. These cones of uncertainty are merely illustrative. Additional work is underway to apply even more rigorous methods to determine actual levels of forecast uncertainty.

Figure 1 clearly denotes a projected SAIDI improvement of up to 60%. The additional projections found in Appendix B illustrate similar findings for SAIFI.

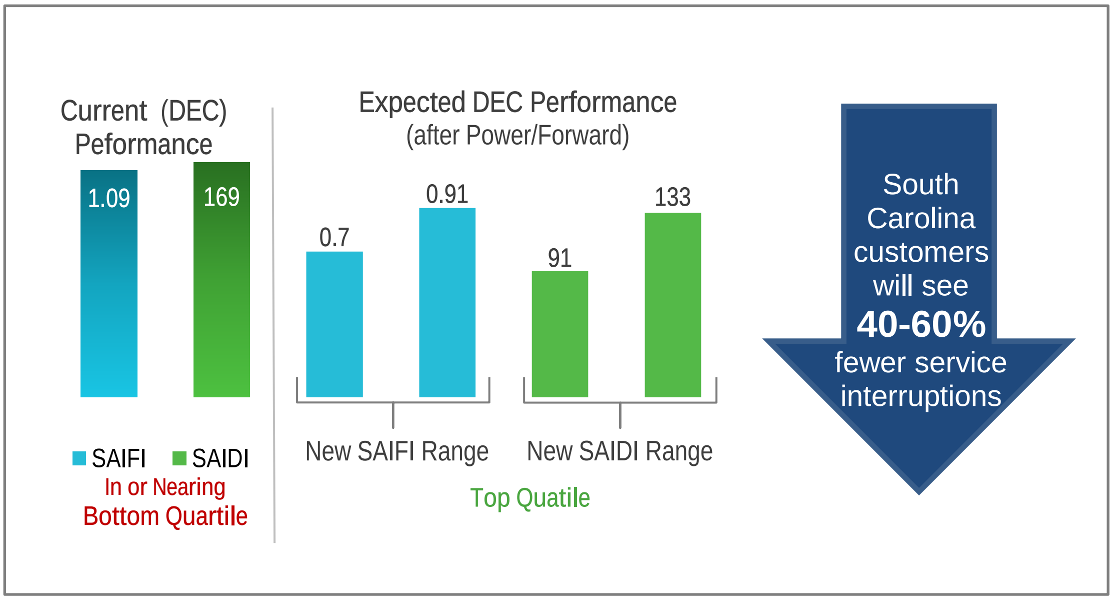


Figure 2 – This data reflects significant improvements that occur in Duke Energy Carolinas' SAIFI and SAIDI reliability performance measures in South Carolina after Power/Forward Carolinas is implemented. Ranges of improved performance are based on historic load and weather information and do not reflect any impacts from changes in weather severity or customer load profiles.)

Similarly, Figure 2 provides a sample of the impact of Power/Forward Carolinas on SAIDI and SAIFI for DEC in South Carolina. Beginning with 2017 year-end values of DEC SAIFI and SAIDI (1.09 and 169, respectively), upon full implementation of Power/Forward Carolinas, Duke Energy expects to see SAIFI and SAIDI improvement in the range of 40-60 percent.

Interestingly, according to J.D. Power research, customers who experience a series of momentary power outages are just as unhappy as those with a sustained power outage.

To achieve fewer outages and greater reliability, businesses and households will necessarily experience an increase in rates as a result of these investments.

Here are a number of actual examples of reliability impacts across our customer base:

1) According to a 2017 study by research economist Dr. Joseph Von Nessen, at current grid performance levels, retail electric customers in South Carolina experience approximately $334 million in annual outage costs related to normal service interruptions (non-major events), with businesses making up 98 percent of this impact. These business losses could have represented potential costs savings and reinvestments in growth and new hiring by local South Carolina businesses.

2) An industrial customer reported actual lost profit margins of nearly $70,000 from four hours of outage time following Hurricane Irma.

3) A Materials Producer reported $3.5M loss due to a single plant interruption

Clearly, improvements from the Power/Forward Carolinas investment will result in fewer outages and blinks and provide much more reliable power for customers in South Carolina.

Severe weather events are increasing, and the threat of cyber and physical attacks on the grid are real.

Our grid is responding to an increasing number of storms at a time when reliability is more essential to customers and the economy than ever before. The National Weather Service has cited an 80 percent increase in the number of severe weather events impacting the U.S. from 2000 to 2016, which has led to an increase in major event days (MEDs). Wind and ice storms are two of the leading causes of outage conditions for our power systems, and flooding has also become an increasing concern.

A **major event day (MED)** is a day in which a major reliability event, such as a hurricane or major ice storm, causes an electric utility to shift into "storm restoration mode" in order to adequately respond.

Combined with this, the threat of cyber and physical attacks on the grid are real, and of increasing concern. According to a USA Today analysis of federal energy records, about once every four days part of the nation's power grid is struck by a cyber or physical attack, one which could leave millions in the dark. As one of the largest investor-owned utilities in the U.S., Duke Energy is a prime target for increasingly sophisticated cyber crimes. Power/Forward Carolinas investments are designed to mitigate the impact of major storm events, as well as to harden and defend the grid against critical cybersecurity risks.

Technology is now available to enable a transition from a mechanical grid that is aging to a more modern, digitized grid.

We're making smart investments to better serve customers and to promote South Carolina's drive for continued growth and development. With an increasingly global economy and greater need for consistent, reliable power, now is the time to transition to a modern, digitized grid. This transition includes replacing outdated, analog infrastructure with advanced digital technology that enables a

21st-century economy.

For example, self-optimizing grid technologies will identify and isolate faults in near-real time and rapidly re-route power, reducing the average number of customers impacted by an outage to a fraction of what occurs today.

Intelligent sensing will remotely monitor grid heath and improve overall system operations and maintenance activities – preventing unplanned outages before they occur. And the deployment of digital smart meters will empower customers with increased options and services to help customers take control of their energy usage.

Just as the past 10 years modernized the way Duke Energy generates electricity, investments over the next 10 years will leverage new technologies to create a smarter, more resilient and more secure electric power system that delivers the services our customers expect and deserve.

2.0 SEVEN STRATEGIC PROGRAMS

The Power/Forward Carolinas plan is comprised of seven strategic programs. Deploying these improvement programs will enable us to better meet our customers' needs and expectations, including better managing their energy usage and reducing outage frequency and duration. It will also enable us to accelerate storm restoration, protect against physical and cyber security threats and better manage distributed energy resources (DER) and energy storage technologies.

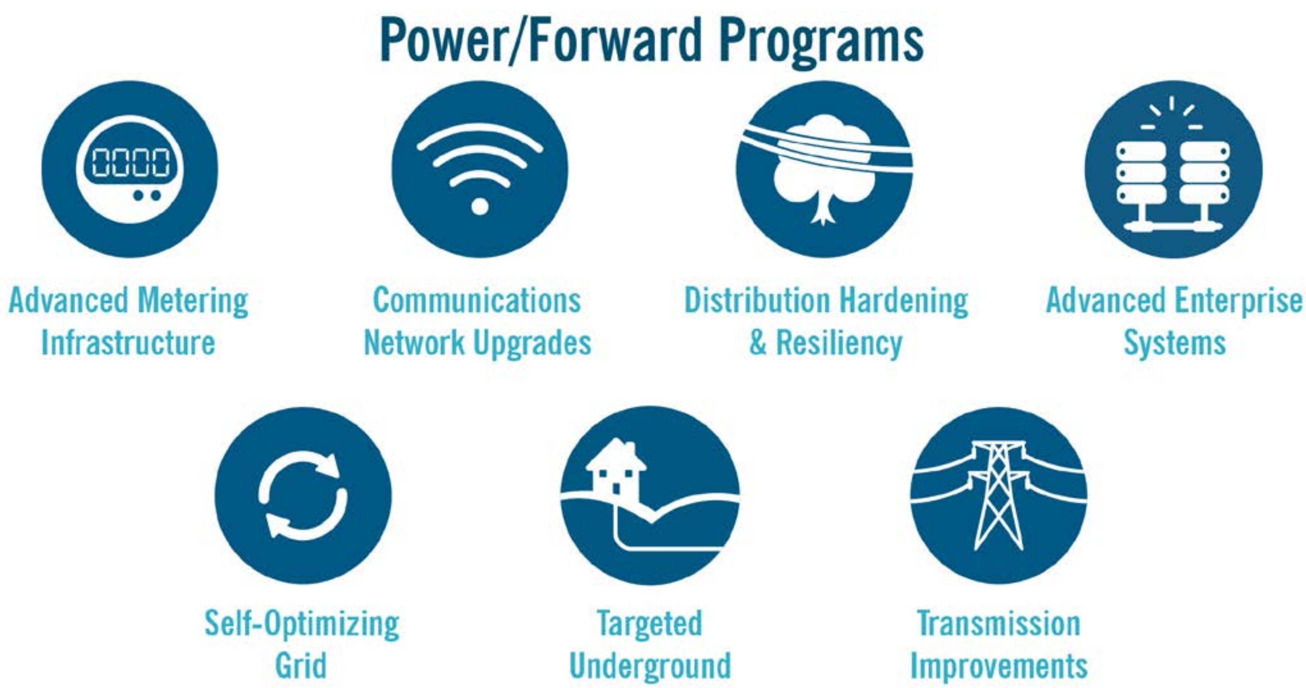


Figure 3 – Power/Forward Carolinas seven strategic programs

2.1 Power/Forward Carolinas Strategic Programs

Targeted Underground (TUG)	Relocate strategically targeted lines with higher reliability risk from overhead to underground construction to decrease outages, reduce momentary interruptions (blinks), improve major storm restoration time, and improve customer satisfaction.
Distribution Hardening & Resiliency	Upgrading equipment to lower system outage risk due to asset failure (hardening) and to minimize the impacts of events and improve ability to recover rapidly when events occur (resiliency). This program also addresses asset end-of-life opportunities, system design, and physical and cyber security.
Self-Optimizing Grid (SOG)	Building a smarter, more resilient distribution system that isolates problems in near real-time and re-routes power to exponentially reduce impacts to customers and communities. To enable SOG functionality, circuits will have automated switches approximately every 400 customers, or 2 megawatts (MW) peak load, or 3 miles in circuit segment length.
Advanced Metering Infrastructure (AMI)	Deploying digital smart meters and associated communication devices to provide enhanced customer billing and payment options, detailed usage data, and energy-savings tools, as well as enhanced operational functions such as automated meter-reading, remote service connections and outage detection.
Communication Network Upgrades	Providing high-speed, high bandwidth, secure communication pathways (fiber optic and wireless) for the increasing number of smart components, sensors, and remotely activated devices on the transmission and distribution systems.
Advanced Enterprise Systems	Upgrading systems that manage grid devices, monitor equipment health, analyze data from monitoring sensors to improve system efficiency and operations, and enable grid self-optimizing technologies.
Transmission Improvements	Deploying equipment upgrades, flood mitigation, physical and cyber security and system intelligence to make a smarter, more reliable and secure transmission system.

2.2 Estimated Program Costs and Operational Benefits

Duke Energy expects to invest $3 billion in South Carolina to implement the plan's seven strategic programs over a 10-year period. In general, our standard planning and prioritization processes will be used for Power/Forward Carolinas programs. For new transformational programs (e.g., Self-Optimizing Grid, Targeted Underground), we have developed new guidelines to provide additional guidance on the planning, prioritization and execution of these programs.

The annual Power/Forward Carolinas planning process will identify the most cost-effective solutions to accomplish program objectives and maximize value to customers.

Program-level cost drivers and methodologies for each of the seven strategic programs are described below with supplemental information provided in *Appendix A, Power/Forward Carolinas Cost Estimate Supplemental Information.*

Program details and cost estimates outlined below represent the initial 10-year cost estimates for Power/Forward Carolinas and are not necessarily the full population of detailed projects that will be a part of the plan. Some projects are further along in the planning cycle and have more detailed budgets, while others are higher-level estimates of future efforts. Each year, we will scope and budget the work for the following year, which may shift funding among programs and projects, shift projects earlier or later in the timeline, or add or remove projects as applicable based on resource availability and benefit achievement.

10 Year Power/Forward Initiative Capital Investments

Targeted Underground	$1.3 B
Distribution Hardening and Resiliency	$704 M
Transmission Improvements	$533 M
Self-Optimizing Grid	$385 M
Advanced Metering Infrastructure	$107 M
Communications Network Upgrades	$ 74 M
Advanced Enterprise Systems	$ 23 M
Total	**$3.1 B**

Program Cost Estimate Details

Targeted Underground – ($1.3 billion) The bulk of this program focuses on fused tap lines that run through residential neighborhoods. For this work, total cost estimates are based on unit costs of $400K-$500K per mile to convert overhead lines to underground. Feeder level undergrounding is much more costly, typically running more than $1 million per mile. These costs are based on industry benchmarking for tap line undergrounding, and the scope of approximately 2,300 miles for South Carolina. These costs include engineering and construction, along with brownfield development costs to engage and negotiate with all affected customers. For example, the company will employ dedicated land agents and engagement specialists to secure easements, and estimates the need to secure ~7,500 easements across the enterprise in 2018 alone.

Distribution Hardening & Resiliency – ($704 million) This program comprises a variety of work streams, many based on historical unit cost averages per mile or foot. Examples in this category include cable replacement (767 miles at approximately $150K per mile) and deteriorated conductor replacement (855 miles at approximately $100K per mile). Others are based on historical unit cost averages per unit upgraded. Examples in this category include transformer retrofit (49,000 at approximately $1,200 per unit) and pole replacement (5,500 poles at approximately $3,300 per pole). Several programs do not fit into either category and their costs are based on subject matter expertise. An example of this is the area of vulnerability[1] program (five locations at approximately $5 million per area).

Transmission Improvements – ($533 million) This program is made up of a variety of transmission grid reliability programs. Equipment engineers and subject matter experts have identified specific assets that need to be replaced to ensure continued transmission resiliency and reliability. There are 35 reliability programs identified to replace various types of equipment on transmission lines and in substations. The majority of the programs are based on historical unit cost averages per unit replaced. Examples in this category include breaker replacements, substation transformer replacements, and line equipment replacements and hardening. These cost estimates are asset-based, however work will be implemented on a substation or site basis. Other programs such as Condition-Based Monitoring (CBM), Phasor Measurement Units, Health and Risk Management (HRM) and physical/cyber security programs, are project-based and have standalone cost estimates.

Self-Optimizing Grid – ($385 million) Approximately 50 percent of the distribution circuits (~460 circuits) in South Carolina, serving approximately 80 percent of customers in the state, will be upgraded to self-optimizing grid guidelines for switch automation, connectivity, and capacity. Average unit cost per circuit is estimated at $840K and is based on historical cost averages for similar types of work. The standard deviation from this average is large, with costs ranging from $200K to $2 million per circuit. Many circuits already have appropriate connectivity and capacity and will only require switch automation. Other circuits will require significant capacity upgrades and new circuit ties.

[1] Area of Vulnerability is defined as "a portion or portions of the electric distribution system where the risk and/or probability of a system disturbance results in an impactful service disruption to the customer(s) and correspondingly high economic, societal, or reputational impact."

Advanced Metering Infrastructure – ($107 million) These costs are based on the approximate South Carolina allocation of the standalone cost estimates for AMI in the North Carolina 2017 Smart Grid Technology Plan Updates in Docket No. E-100, Sub 147.

Communications Network Upgrades – ($145 million) This program is made up of a variety of work streams and the costs identified are the approximate allocations for Duke Energy Carolinas and Duke Energy Progress in South Carolina. Some programs are project-based and have standalone enterprise cost estimates. For example, the Land Mobile Radio End-of-Life project (in the Mission Critical Voice Communications workstream) is estimated at $130.3 million total (approximately $29.5 million allocated to South Carolina) and the Vehicle Area Network project estimated at $13.8 million total (approximately $3.1 million allocated to South Carolina). Other communications efforts have been estimated based on historical unit upgrade cost averages. For example, the tower and shelter upgrades are estimated at $500K per tower and $150K per shelter, based on historical average costs. These cost estimates are refined as specific vendor costs become available. In South Carolina, DEC and DEP plan to replace approximately 11 towers ($500K per tower) and 23 shelters ($150K per shelter) during the 10-year plan ($9.0 million) with the remainder of the budget allocated to power supply replacement where necessary ($1.8 million). This program's cost estimates have changed considerably since the initial 10-year forecast was developed. The figures above represent the most current planning and scoping estimates.

Advanced Enterprise Systems – ($23 million) These cost estimates are based on the stand-alone cost estimates for each enterprise system program (e.g., Distribution Management System, Outage Management System, SCADA). Costs identified are the approximate allocations for DEC South Carolina and DEP South Carolina.

Additional Operational Benefits

Beyond the positive benefits the Power/Forward Carolinas plan generates for the state (discussed in Section 3), additional value is expected in the form of cost savings for South Carolina distribution operations. Based on the reduction in outage events resulting from the 10-year grid improvement plan, we estimate approximately $10.6 million in additional annual benefits from reliability-related operation and maintenance (O&M) savings opportunities.

These outage event reduction O&M savings include:

- vegetation management ($3.7 million)
- outage restoration activities ($3.8 million)
- major storm event restoration ($3.1 million)

These values reflect O&M cost savings beginning in year 11 and do not include O&M cost savings resulting from our AMI program.

We anticipate additional Power/Forward Carolinas plan benefits resulting from:

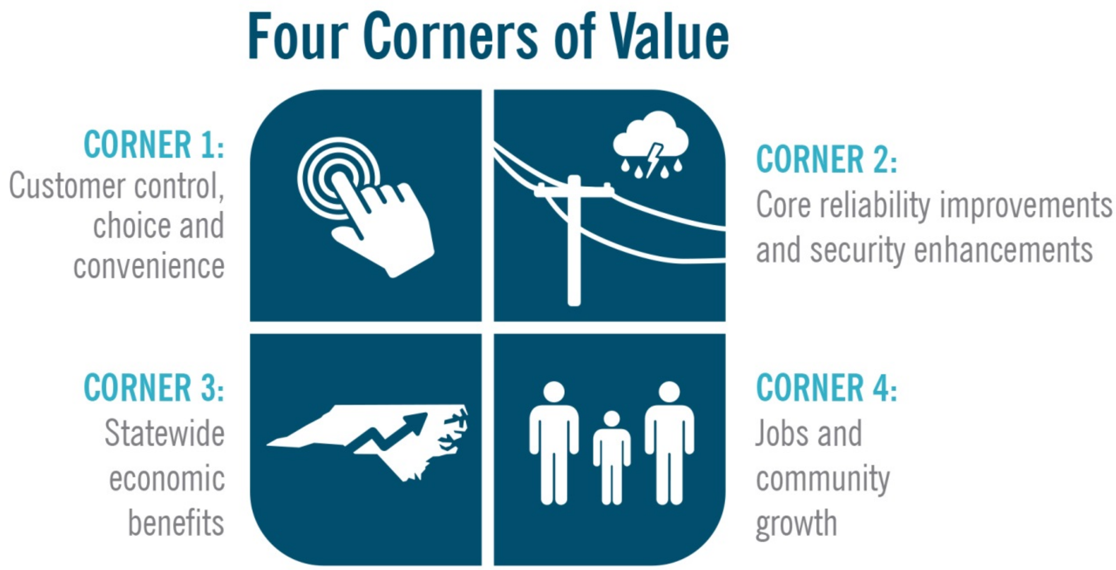
- Improved management of private distributed energy resources as customer adoption grows (e.g., grid-connected rooftop solar);
- Increased protection from cyber and physical security attacks

- Improved environmental impacts from:
  - Reduced risk of oil spills and gas leaks due to applicable equipment replacements (estimated to avoid over 1,300 gallons of oil spilled and 100 oil-spill events annually); this will also result in lower environmental clean-up costs (estimated to result in more than $150,000 in annual savings across the Carolinas);
  - Reduced risk of avian collisions as a result of undergrounding overhead facilities (this will also result in cost reductions associated with levied fines relating to eagle and other bird impacts).

These are only ancillary benefits. A discussion about the direct customer and state-wide value of our plan is provided in the following section.

3.0 FOUR CORNERS OF VALUE

Duke Energy has proudly served customers in the Carolinas for more than 100 years. As we work to continually improve that level of service and innovate to meet evolving customer needs, we're launching new products and services, improving core electric power reliability, driving economic growth, and developing jobs and communities. We identify these areas of value, or "four corners," below:



Power/Forward Carolinas Value Proposition:

Below are several examples showing the value proposition Power/Forward Carolinas will bring in each of the four corners.

Corner 1: Customer control, choice and convenience

- Access to new service and billing options like Pick Your Due Date and Usage Alerts
- Availability of detailed daily usage data, making it easier to use energy more efficiently
- Option to stop/start service remotely
- Improved outage response times and quicker repairs

Corner 2: Core reliability improvements and security enhancements

- Reduction in regular-service outages by 40 to 60 percent
- Estimated 30 percent reduction in the frequency and duration of major event outages, including named storms and hurricanes
- Increased protection from cyber and physical security attacks

Figure 4 shows the historic 10-year average numbers of customer interruption and minutes of interruption due to major events which are not reflected in SAIDI and SAIFI measures. Based on our analysis, the improvements implemented as part of Power/Forward Carolinas would have reduced these impacts by one third.

REDUCTION IN MAJOR STORM IMPACTS	Customers interrupted (CI)	Customer Mins Interrupted (CMI)
10-year historical average, SC	232,271	210 million
Estimated reduction (%)	33%	30%
Forecasted impacts after Power/Forward Carolinas	**154,847**	**147 million**

Figure 4 – Average annual MED events and duration anticipated in South Carolina (DEC and DEP) before and after Power/Forward Carolinas

Consider again the long and widespread outages stemming from Hurricane Matthew. This same analysis applied to Matthew shows a significant reduction in grid damage and associated restoration.

Figure 5 illustrates that improvements implemented as part of Power/Forward Carolinas would have eliminated more than 30% of the combined power outages experienced in Hurricane Matthew. This reduction allows customers to get back to work more quickly or better support their loved ones who were impacted.

Hurricane Matthew (2016)

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	27%	28%	33%
DEC SC	11%	21%	28%

Figure 5 – Number and duration of Hurricane Matthew power outages in SC that would have been avoided with Power/Forward Carolinas implementation

Corner 3: Statewide economic benefits

- The grid investment plan will result in a total economic output of $5.8 billion over the 10 years of implementation.
- The project represents a nearly 10 percent increase in total capital investment for the state for each of the next ten years. Put another way, the average annual capital investment of the grid improvement project – $333 million – would rank 2nd among all capital investment announcements by the S.C. Department of Commerce in 2016.
- By 2028, the grid investment plan is projected to provide reliability improvements to South Carolina households and businesses that will total between $503 million and $724 million annually from reduced outage-related costs.
- The project will generate around $116 million in in new annual tax revenue for the state, and help attract new industry and business to make our communities and economies stronger.

Corner 4: Jobs and community growth

- An average of nearly 3,300 new jobs created for the state of South Carolina through the Duke Energy grid investment, which will expand to more than 5,400 jobs during the project's peak year.
- Almost $200 million in new salaries and wages will be generated, on average, during each year of the project, with nearly $315 million being generated during peak construction years (totaling approximately $2 billion over the ten years of the plan).

As highlighted in our discussion of Power/Forward Carolinas program costs (Section 2.2), the grid improvement plan will mean direct capital investments of more than $3 billion over the 10-year plan. This level of direct investment will generate $5.8 billion in total economic output for the state of South Carolina throughout the investment period. Duke Energy's capital investments and activity related to reliability improvements will generate more than $116 million in additional state tax revenues

Capital investments will also support more than 5,400 jobs across the state during the project's peak year, with Duke Energy expanding total employment to 2,400 direct employees and contractors to support Power/Forward Carolinas.

Duke Energy's contribution to statewide economic growth over the next 10 years is roughly equivalent to three major automotive manufacturing announcements in the state.

Combined Value for South Carolina Customers and Communities

The combined value that Power/Forward Carolinas generates for South Carolina customers can be illustrated in the following figure.

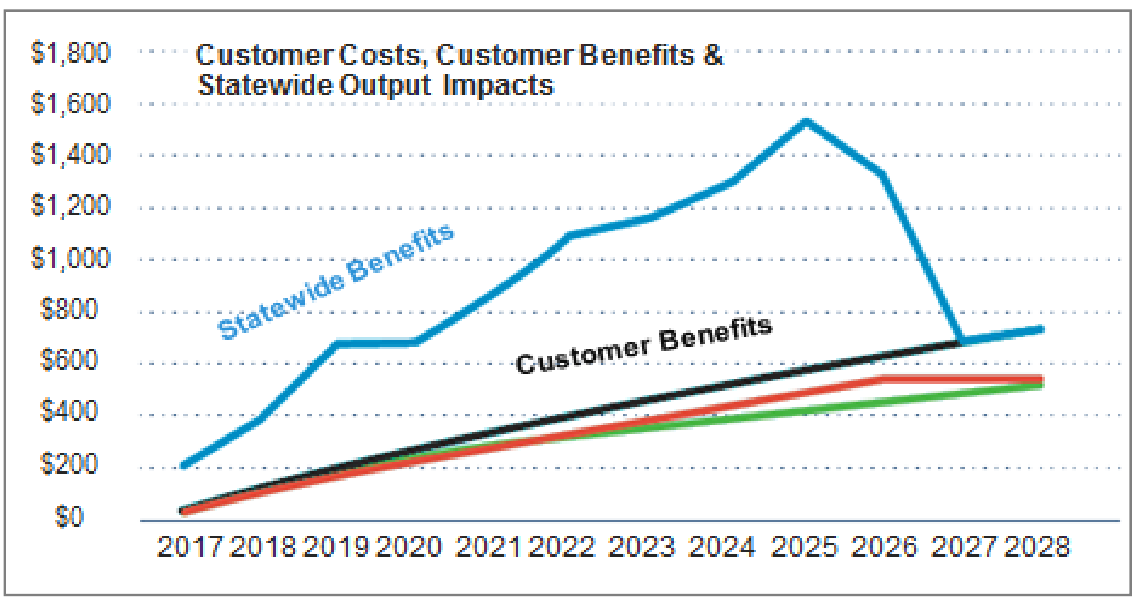


Figure 6 – Customer costs and benefits compared to statewide output impacts (in millions of nominal dollars)

- Customer cost: increased electricity rates
- Customer benefits: Reduction in outage-related costs
- Customer benefits: Reduction in outage-related costs plus potential increase in business sales
- Customer benefits: Total change in gross output

Figure 6 charts four dimensions of economic impacts (in millions of dollars) over the 10-year plan period.

1) **Customer Cost** (red line) – charts the contributions of South Carolina customers for the Power/Forward Carolinas investments; this line is a function of electric rate increases over time.
2) **Baseline Customer Benefit** (green line) – charts the value of outage-related costs customers avoid as a result of improved grid reliability; this is Corner 3 value and is a function of the decreasing number of power interruptions and outage times.
3) **Additional Customer Benefit Opportunity** (black line) – charts the baseline customer benefits (illustrated by the green line) plus the additional potential value from converting those baseline savings into additional customer business profits; this is both a function of improving reliability and a function of how general market forces impact individual customer businesses over time.
4) **Statewide Benefits** (blue line) – charts the total change in gross economic output for the state, as a function of the reinvested business savings (illustrated by additional customer benefit opportunities, black line) as well as new jobs and increased state business activity created over time as a result of direct Power/Forward Carolinas capital investments.

Note that the overall statewide benefits continue to increase throughout the peak investment period year (2025). While the clearly measurable economic impacts from direct capital investments end with the cessation of our direct investing, the benefits resulting from the state's modernized and more reliable grid continue beyond 2028.

The increase in costs borne by customers associated with grid improvements (red line) are expected to continue until all capital investments are completed in 2026. After this point, costs will remain relatively constant going forward. Total annual customer costs in South Carolina will range from $84 million in 2018 to $530 million by 2028. We anticipate reliability improvements (Corner 3 discussion) to begin to generate avoided outage cost savings that could range from $79 million in 2018 to $503 million by the end of 2028 (green line). If these avoided costs were then translated into new sales activity by businesses, reliability benefits could grow as high as $724 million by 2028 (black line). Duke Energy's South Carolina customers could see an annual net benefit of up to $194 million in 2028 as those savings are converted into customer value.

Combining the maximum anticipated benefits from the three corners with all capital investments associated with grid improvement (Corner 4) yields a total potential impact of $10.5 billion for the state of South Carolina over the 10-year period.

4.0 CONCLUSION

South Carolina needs an energy grid that is smarter, more reliable and secure to grow the economy, create jobs and provide the services and energy experience that consumers expect and deserve. Creating this grid requires smart investments today to advance and modernize energy infrastructure to position South Carolina for future success.

The grid has served customers reliably for more than a century, but an aging, analog machine cannot sustain the growing expectations of our digitally-connected society. We must act now and move forward together to build a stronger, more prosperous future for the state.

This defining moment calls for a bold plan. That plan is Power /Forward Carolinas. It will transform the way Duke Energy serves customers, and will position the grid and the state for success now and for years to come.

Power/Forward Carolinas
SUPPLEMENTAL INFORMATION
(APPENDICES)

TABLE OF APPENDICES

Appendix A, Power/Forward Carolinas Cost Estimate Supplemental Information 19

Appendix B, Additional South Carolina Reliability Measures Information …….……....24

Appendix C, Projected Impacts Avoided During Major Storms…..................................25

Appendix D, Measuring the Economic Impact of Reliability Improvements……….……26

APPENDIX A, POWER/FORWARD CAROLINAS COST ESTIMATE SUPPLEMENTAL INFORMATION

The information below is supplied as supplemental information for Power/Forward Carolinas program costs for some of the programs identified in **Table A1**. The program details and cost estimates outlined below represent the initial 10-year cost estimates for Power/Forward Carolinas and are not necessarily the full population of detailed projects that will be a part of plan. Some projects are further along in the planning cycle and have more detailed budgets, while others are higher-level estimates of future efforts. Each year, the company will scope and budget the work for future years, which may shift funding among programs and projects, shift projects earlier or later in the timeline, or add or remove projects as applicable based on resource availability and benefits achievement.

10-Year Power/Forward Carolinas Initiative

Targeted Underground	$1.3B
Distribution Hardening and Resiliency	$704M
Transmission Improvements	$533M
Self-Optimizing Grid	$385M
Advanced Metering Infrastructure	$107M
Communications Network Upgrades	$74M
Advanced Enterprise Systems	$23M
Total	**$3.1B**

Table A1 – 10-year investment for South Carolina programs

Program-level cost drivers and methodologies for each of the seven strategic programs are described in *Section 2.2 Power/Forward Carolinas Program Costs*. The information below provides more granular budgeting details where appropriate.

Self-Optimizing Grid – ($385 million) Using the budget methodology described for Self-Optimizing Grid in *Section 2.2 Power/Forward Carolinas Program Costs*, the following budget has been developed. On average, three to four automated switches will be used for each circuit upgraded to SOG guidelines.

Program	# Circuits	Cost/Unit	Total $M
Self-Optimizing Grid	460	$840,000	$385

			DEC		DEP	
Program Description	**Unit**	**Cost/Unit**	**# Units**	**Total $M**	**# Units**	**Total $M**
Automation	Automated Switches	$50,000	1,300	$65.0	300	$15.0
Capacity & Connectivity	Circuit	$650,000	360	$234.0	110	$71.5
	10-Year SC Total		**DEC**	**$299.0**	**DEP**	**$86.5**
		Grand Total $M		**$385.5**		

Targeted Underground – ($1.3 billion) Using the budget methodology described for Targeted Underground in Section 2.2 Power/Forward Carolinas Program Costs, the following budget has been developed:

Program	Unit	# Units	Cost/Unit	Total $M
Targeted Underground	Miles	2,276	$400-$500K	$1,138

COUNTY	TUG MILES
Abbeville	4.09
Anderson	291.16
Cherokee	38.58
Chester	37.53
Chesterfield	32.03
Clarendon	26.80
Darlington	95.04
Dillon	32.10
Fairfield	2.35
Florence	152.53
Georgetown	8.04
Greenville	529.71
Greenwood	63.18
Horry	2.29
Kershaw	9.11
Lancaster	100.25
Laurens	29.26
Lee	21.35
Marion	45.34
Marlboro	17.31
Newberry	5.43
Oconee	22.63
Pickens	72.11
Spartanburg	410.73
Sumter	106.31
Union	1.10
Williamsburg	38.87
York	80.67

Totals 2,276 miles in SC

Distribution Hardening & Resiliency – ($704 million) Using the budget methodology described for Distribution Hardening & Resiliency in Section 2.2 Power/Forward Carolinas Program Costs, the following budget has been developed:

			DEC		DEP	
Program Description	**Unit**	**Cost/Unit**	**# Units**	**Total $M**	**# Units**	**Total $M**
Transformer Retrofit	Location	$1,152	2,000	$2.3	47,000	$54.1
Cable Replacement	Miles	$148,685	767	$114.0	229	$34.0
Sectionalization	Circuits	$20,000	252	$5.0	101	$2.0
Deteriorated Conductor Replacement / line rebuild	Miles	$100,000	855	$85.5	480	$48.0
Areas of Vulnerability	Locations	$5,000,000	3	$15.0	2	$10.0
Pole Hardening	Poles	$3,333	4,184	$13.9	1,251	$4.2
Capacity	Substations	$10,000,000	3	$30.0	2	$20.0
Live front switchgear and transformer replacement	# devices replaced	$25,000	312	$7.8	125	$3.1
Hazard Tree Removal		$1,000	3,600	$3.6	1,440	$1.4
Feeder Ties (for long duration outages)	Miles	$250,000	350	$87.5	208	$52.0
Open wire secondary replacement	Linear feet	$12	-	-	100,000	$1.2
Oil-filled reclosers replacement	Reclosers	$50,000	132	$6.6	53	$2.7
Underground Riser Retrofit		$1,000	8,640	$8.6	3,456	$3.5
Electronic Recloser	Reclosers	$6,500	132	$0.9	53	$0.3
Hardening and resiliency programs requiring further engineering and scoping (e.g., structural guying, BIL uplift, physical and cyber security improvements, ampacity upgrades, etc.)				$54.8		$32.2
	10-Year SC Total		**DEC**	**$435.6**	**DEP**	**$268.8**
				Grand Total $ M	**$704.4**	

Transmission Improvements – ($2.75 billion NC/SC; $533 million SC) Using the budget methodology described for transmission improvements in Section 2.2 Power/Forward Carolinas Program Costs, the following budget has been developed:

	DEC			DEP		
Program Description	**# Units**	**Cost/ Unit**	**Total $M**	**# Units**	**Cost/Unit**	**Total $M**
Replace T-Oil Breakers w/Gas	400	$300,000	$120.0	200	$300,000	$60.0
Replace 230kV SF6 Breakers	50	$600,000	$30.0			
Replace 500kV Breakers	17	$895,000	$15.2	6	$895,000	$5.4
Replace D-Oil Breakers	500	$125,000	$62.5	400	$125,000	$50.0
Replace CCVTs 25+ or older	300	$22,000	$6.6	700	$22,000	$15.4
Replace RTU Replacement	50	$150,000	$7.5	84	$150,000	$12.6
Replace SBC Breaker Failure Relays	145	$150,000	$21.8			
Replace Electro-mechanical Relays per Terminal	500	$300,000	$150.0	400	$300,000	$120.0
Hybrid Relay Group scheme				116	$100,000	$11.6
Replace First Gen Relays	550	$180,000	$99.0	35	$180,000	$6.3
Install new Digital Fault Recorder (DFR)	3	$250,000	$0.8	10	$250,000	$2.5
Replace Digital Fault Recorder (DFR)	15	$250,000	$3.8	23	$250,000	$5.8
Replace Line Relay Carriers/Transfer Trip	15	$400,000	$6.0	27	$400,000	$10.8
Battery Bank Replacement				300	$15,000	$4.5
Replace Type U Bushings (count per transformer)	250	$100,000	$25.0	79	$102,000	$8.1
Bushings (count per transformer)				100	$102,000	$10.2
Replace Transformers - 1 PH & 3 PH	100	$2,000,000	$200.0	100	$2,000,000	$200.0
Replace Trench Reactors				46	$119,000	$5.5
Upgrade Load Tap Changer (LTC)	15	$300,000	$4.5			
Replace Silica Carbide Arresters	2500	$24,000	$60.0	250	$22,000	$5.5
Replace Voltage Regulators - 1PH	15	$70,606	$1.1			
Replace Voltage Regulators - 3PH	10	$240,000	$2.4	71	$350,000	$24.9
Replace Cap & Pin Insulators Bus Supports & Standoffs	4000	$25,000	$100.0			
Upgrade Transformer Coolers	21	$300,000	$6.3			
Emergent Equipment Replacements	10	$20,000,000	$200.0	8	$20,000,000	$160.0
Replace Substation Circuit Switchers				70	$150,000	$10.5
Replace OB Arresters				44	$22,000	$1.0
Wood Substations, Rebuild (incremental cost of wood)				48	$1,500,000	$72.0

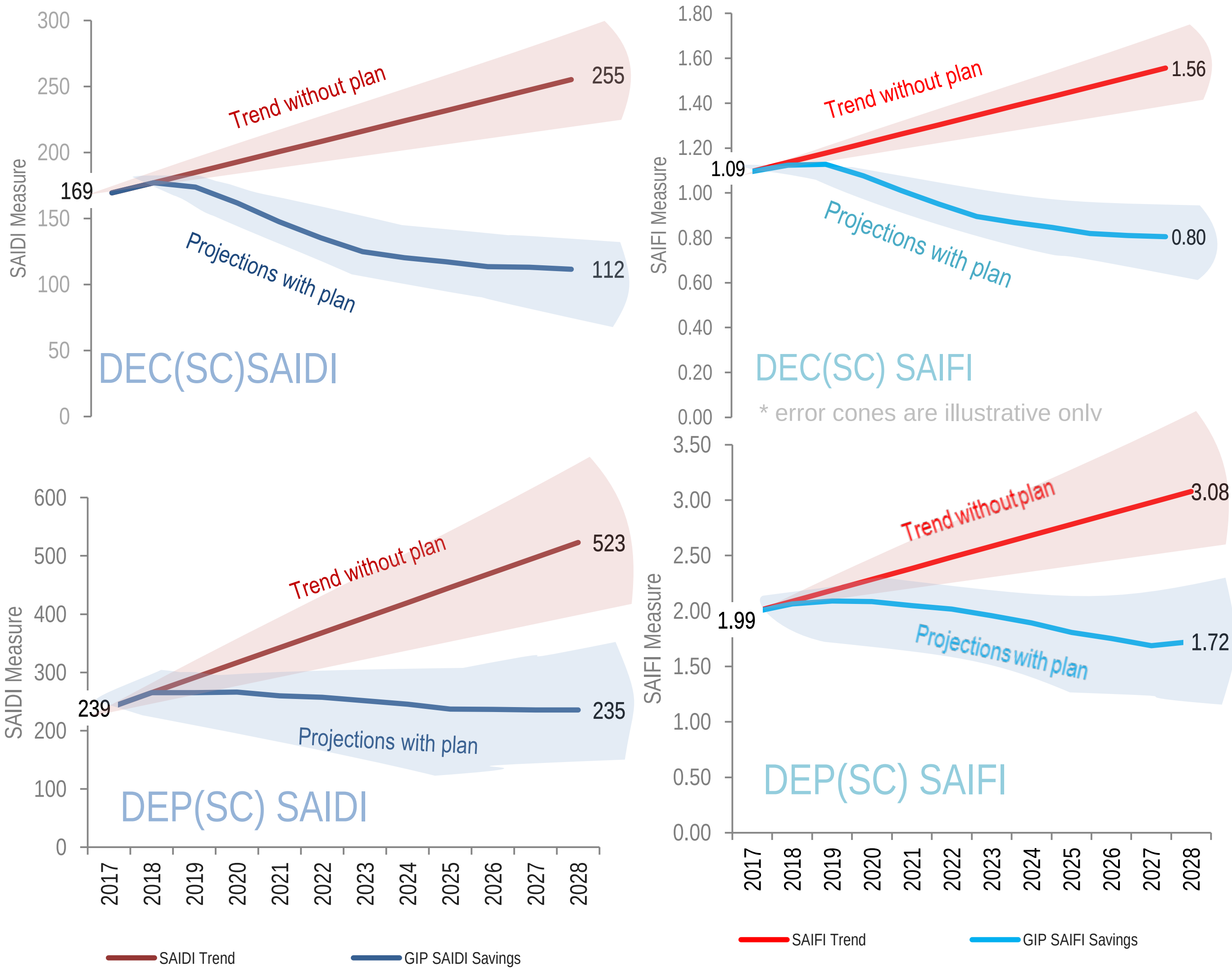
	DEC			DEP		
Program Description	**# Units**	**Cost/ Unit**	**Total $M**	**# Units**	**Cost/Unit**	**Total $M**
Wood Pole Replacement	5000	$25,000	$125.0	7000	$25,000	$175.0
T-Line Rebuilds (Per Mile)	150	$1,500,000	$225.0			
Substation Animal Mitigation	80	$250,000	$20,000,000	60	$250,000	$15,000,000
Remote Sectionalizing Switches	75	$500,000	$37,500,000	100	$500,000	$50,000,000
T-Line Static Replacements (Per Mile)	250	$150,000	$37.5	300	$150,000	$45.0
T-Line Str/Tower Replacements	100	$189,000	$18.9	420	$189,000	$79.4
Replace T-Line Switches	100	$250,000	$25.0	132	$250,000	$33.0
Replace Cap & Pin Insulators Switches	400	$25,000	$10.0	130	$250,000	$32.5
Replace Polymer Insulators with Porcelain (Per Mile)	56	$200,000	$11.2	200	$300,000	$60.0
Physical & Cyber Security Improvements			$185,000,000			$102,000,000
System Intelligence HRM & CBM			$30,550,000			$16,450,000
		DEC Total:	**$1,575**		**DEP Total:**	**$1,167.3**
			Grand Total $ M:	**$2,742.2**		

Communications Networks Upgrade – ($145 million) Using the budget methodology described for Communication Networks Upgrade in Section 2.2 Power/Forward Carolinas Program Costs, the following budget has been developed**:**

Project Name	Totals $M
DEC Mission Critical Transport Network	75.6
DEC Next Gen Cellular	9.0
DEE Vehicle Area Network	3.1
DEE Asset/Network & GIS Management	5.0
DEC Mission Critical Voice Communications	29.5
DEC Towers, Shelters & Power Supplies	10.6
DEC BizWAN	1.1
DEC GridWAN	11.2
Totals	145.3

APPENDIX B, ADDITIONAL SOUTH CAROLINA RELIABILITY MEASURES INFORMATION

Figures below represent the 10-year reliability measure projections for SAIDI and SAIFI for Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) in South Carolina with and without Power/Forward Carolinas implementation.



About the Reliability Measures Projections

The 10-year "trends without plan" projections were developed from five years of historical non-MED outage data to ensure a sample size capable of producing an 80 percent confidence level. The mean value (μ) of each of the data set (DEC and DEP) was calculated and projected using linear regression techniques.

To acknowledge the increasing uncertainty of these projections the further out in time they are projected, cones of uncertainty are overlaid for each reliability measure forecast. These cones of uncertainty are merely illustrative as we are working to apply rigorous methods to determine actual levels of forecasts uncertainty.

The 2017 starting value is a projection from the 2016 year end SAIDI and SAIFI measures for DEC and DEP.

APPENDIX C, PROJECTED IMPACTS AVOIDED DURING MAJOR STORMS

The tables below denote the forecasted customer impacts from named storms and major weather events (events that caused multi-day outages) that could have been avoided during the past three years with Power/Forward Carolinas implementation. Customer Interruptions (CI) Eliminated, Customer Minutes of Interruption (CMI) Eliminated and Outages Eliminated are shown in percentage reduction of actual event totals.

February 2014 Ice Storm

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	20%	26%	34%
DEC SC	17%	19%	24%

March 2014 Ice Storm

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	53%	65%	47%
DEC SC	37%	31%	28%

Winter Storm Remus (2015)

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	40%	40%	43%
DEC SC	46%	29%	24%

Winter Storm Octavia (2015)

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	30%	23%	26%
DEC SC	28%	27%	27%

Hurricane Hermine (2016)

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	23%	19%	23%
DEC SC	NA	NA	NA

Hurricane Irma (2016)

South Carolina	% CI Eliminated	% CMI Eliminated	% Outages Eliminated
DEP SC	36%	27%	34%
DEC SC	28%	27%	22%

APPENDIX D, MEASURING THE ECONOMIC IMPACT OF RELIABILITY IMPROVEMENTS

Measuring Costs Savings Associated with Core Reliability Improvements

To estimate businesses and households cost savings associated with core reliability improvements (Corner 1), the Von Nessen study used SAIFI and SAIDI projections for non-major events along with South Carolina customer segment data (i.e., numbers of residential, business, and commercial customers as inputs) in the Interruption Cost Estimate Calculator (ICE) developed by the U.S. Department of Energy and Lawrence Berkeley National Laboratory.

The ICE model specifically calculates the average interruption cost for residential, business, and commercial customers for a given SAIFI/SAIDI data pair using a regression model that takes into account factors such as the duration of the outage, the industry affected, household demographics patterns, and various seasonal factors. By estimating the difference in interruption costs associated with current SAIFI/SAIDI projections with and without implementation of the Power/Forward Carolinas improvements, the annual direct cost savings resulting from our proposed grid improvements can be determined.

Measuring Costs Savings Associated with Reduced Major Storm Impacts

To estimate businesses and households cost savings associated with *reduced major storm impacts* (Corner 2), the Von Nessen study used the annual averages for customer interruptions (CI) and customer minutes interrupted (CMI) associated with Major Event Days (MEDs). From this, Dr. Von Nessen projected estimates of the avoided CI and CMI anticipated from our Power/Forward Carolinas improvements. Again, the data was used in the DOE/LBNL ICE tool to estimate the direct cost savings as improved infrastructure comes on line over the 10 year investment period.

Measuring Additional Statewide Economic Impacts

Note that these direct cost savings (Corner 3) do not capture the full economic impact of our reliability improvements. When South Carolina businesses experience these cost reductions, over time they will begin to expand their economic activities through additional purchases of raw inputs and the hiring of additional employees (Corner 4 – *statewide benefits*). To estimate this additional economic activity, the IMPLAN model was used.

Both the reinvested business loss savings and the indirect and induced economic stimulus represent new economic activity that is the result of grid reliability improvements.